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Dividends From Wood Research

Recent Publications

July–December 1992

Explanation and Instructions

"Dividends From Wood Research" is a semiannual listing of recent publications resulting from wood utilization research at the Forest Products Laboratory (FPL). These publications are produced to encourage and facilitate application of Forest Service research. This issue lists publications received from the printer by the FPL Publications Section between July 1 and December 31, 1992.

Each publication listed in this brochure is available through at least one of the following sources.

Available from FPL (indicated by an order number before the title of the publication): Quantities limited. Circle the order number on the blank at the end of the brochure and mail or FAX the blank to FPL.

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List of Categories

Publications are listed in this brochure within the following general categories:

- Biodeterioration and Protection
- Energy
- Engineering Properties and Design Criteria
- Fiber and Particle Products
- Fire Safety
- General
- Microbial and Biochemical Technology
- Mycology
- Processing of Wood Products
- Pulp, Paper, and Packaging
- Timber Requirements and Economics
- Tropical Wood Utilization
- Wood Bonding Systems

Biodeterioration and Protection

1. Corrosion of Nails in CCA- and ACA-Treated Wood in Two Environments

Baker, Andrew J.

1992. Forest Prod. J. 42(9): 39–41.

In 1973, a study was started on the corrosion of various nails in waterborne-preserved-treated wood used in construction, especially wood foundations. At that time, there was little information on the long-term corrosion of nails in wood treated with ammoniacal copper arsenate or chromated copper arsenate. Two exposure conditions were selected for the study. One exposure was chosen to produce a corrosion rate higher than that expected in wood foundations. The other exposure was chosen to simulate a wood foundation exposed to weather and wet soil. This paper reports the results of this 1973 study.

2. Decay Resistance of Wood Removed From Poles Biologically Treated With *Trichoderma*

Bruce, Alan; King, Bernard; Highley, Terry L.

1991. Holzforschung. 45(4): 307–311.

Wood blocks removed from a distribution pole previously treated with a biological control product were exposed in soil-block tests to selected basidiomycetes. The blocks were removed from regions of poles where *Trichoderma* colonization had been confirmed by extensive sampling and computer mapping of microbial inhabitants. The results indicate that material from pole interiors colonized by *Trichoderma* is able to resist decay by *Lentinus lepideus* and *Antrodia carbonica*. However, any decay prevention was lost when the wood was steam sterilized prior to exposure to the basidiomycetes. This paper discusses the implications of the results for the use of biological control of internal decay in creosoted poles.

3. Fungal Decay Resistance and Dimensional Stability of Loblolly Pine Reacted With 1,6-Diisocyanatohexane

Chen, George C.

1992. Wood Fiber Sci. 24(3): 307–314.

We are searching for reactive chemicals that are able to cross-link with wood without damaging the mechanical properties of wood, that produce no byproducts in wood, and that result in good decay resistance and dimensional stability. One group of cross-linking compounds that meet these criteria is the diisocyanates. Although reaction of diisocyanates with wood has been reported, evidence of cross-linking, decay resistance, and dimensional stabilization of the modified wood has never been established. The purpose of this study was to report evidence of cross-linking between wood and 1,6-diisocyanatohexane and to investigate fungal decay resistance and dimensional stabilization of the modified wood.

4. Fungal Resistance of Loblolly Pine Reacted With Methyl or Phenyl Isothiocyanate

Chen, George C.

1992. *Holzforschung*. 46(1): 77-80.

In our ongoing investigation of protecting wood against biodegradation through bonding with biocides, we are searching for potential biocides with reactive functional groups that can react with hydroxyl groups of wood cell wall polymers. Methyl isocyanate is a known fungicide and has been evaluated as a fumigant in the remedial treatment of decayed telephone poles. The purpose of the study reported here was to determine the fungal decay resistance of wood reacted with methyl or phenyl isothiocyanate.

5. Early Detection of Brown-Rot Decay in Southern Yellow Pine Using Monoclonal Antibodies

Clausen, Carol A.; Green, Frederick III;

Highley, Terry L.

1991. In: Rossmore, H.W., ed. *Biodeterioration and biodegradation 8: Proceedings of the 8th International biodeterioration and biodegradation symposium*; 1990 August 26-31; Windsor, ON, Canada. New York: Elsevier Applied Science: 412-414.

The goal of this study was to develop an immunodiagnostic procedure capable of detecting incipient brown-rot decay before significant structural damage has occurred. The ideal detection system should meet several criteria: (1) specificity without cross-reactivity, (2) rapid, (3) adaptable as a field test, (4) inexpensive, (5) small sample size, and (6) multiple samples with automated readings.

6. Conditions for Carpogenesis and Basidiosporogenesis by the Brown-Rot Basidiomycete *Gloeophyllum trabeum*

Croan, Suki C.; Highley, Terry L.

1992. *Mater. Org.* 27(1): 1-9.

This study was conducted to provide a better understanding of the factors that regulate and control in vitro production of basidiospores. The objective was to describe the best conditions for carpogenesis and basidiosporogenesis of *G. trabeum*. Ultimately, this information is necessary for mass production of basidiospores to determine the effect of various potential inhibitors of basidiospore germination.

7. Test Assemblies for Monitoring Decay in Wood Exposed Above Ground

De Groot, Rodney C.

1992. *Int. Biodeterior. Biodegrad.* 29: 151-175.

The objective of this study was to identify an above ground test protocol for wood and wood-based products that would be conducive to rapid decay, would exhibit minimal variation among replicates, and would lend itself to quantifiable, nondestructive testing in the field.

8. Alternative Species and Preservatives for Wood Roofing: Laboratory Decay Studies

De Groot, Rodney C.; Woodward, Bessie M.;

LeVan, Susan.

1992. *Forest Prod. J.* 42(11/12): 57-60.

The objective of this study was to evaluate the decay resistance of three candidate wood species treated with preservatives.

9. Ultrastructural Characterization of the Hyphal Sheath of *Postia placenta* by Selective Removal and Immunogold Labeling

Green, Frederick III; Clausen, Carol A.; Larsen, Michael J.; Highley, Terry L.

1991. In: Rossmore, H.W., ed. *Biodeterioration and biodegradation 8: Proceedings of the 8th International biodeterioration and biodegradation symposium*; 1990 August 26-31; Windsor, ON, Canada. New York: Elsevier Applied Science: 530-532.

The objectives of this study were to solubilize and selectively remove hyphal sheath components from inert substrates using detergents (Triton X-100 or SDS), lipid solvents (alcohol or acetone), or enzymes (pronase or laminarinase), and to localize sites of hemicellulase activity using immunogold labeled Mabs to *P. placenta* xylanase by SEM.

10. Degradation of Cellulose by Brown-Rot Fungi

Highley, Terry L.

1991. In: Rossmore, H.W., ed. *Biodeterioration and biodegradation 8: Proceedings of the 8th International biodeterioration and biodegradation symposium*; 1990 August 26-31; Windsor, ON, Canada. New York: Elsevier Applied Science: 529-530.

This paper presents an overview of the decomposition of cellulose by brown-rot fungi—the most important and destructive form of decay of wood in service.

11. Progress in Understanding How Brown-Rot Fungi Degrade Cellulose

Highley, T.L.; Illman, Barbara L.

1991. *Biodeter. Abstracts*. 5(3): 231-244.

This paper presents an overview of work to date on the decomposition of cellulose by brown-rot fungi. Particular attention is given to the effects of these fungi on cellulose ultrastructure, to production of degradative enzymes, and to possible involvement of oxidative degradative metabolites.

12. Oxidative Degradation of Wood by Brown-Rot Fungi

Illman, Barbara L.

1991. In: Pell, Eva J.; Steffen, Kenneth L., eds. *Active oxygen/oxidative stress and plant metabolism*; Proceedings, 6th annual Penn State symposium in plant physiology; 1991 May 23-25; Philadelphia: Penn State University. Rockville, MD: American Society of Plant Physiologists: 97-106. *Current topics in plant physiology: An American Society of Plant Physiologists Series*. Vol. 6: 97-106.

Brown-rot fungi are Basidiomycetes that remove cellulose and other polysaccharides from wood, leaving an amorphous, brown, crumbly residue that is composed largely of lignin, hence the name brown rot. Decay by brown-rot fungi is by far the most serious type of damage to wood in service. These fungi cause structural failure before losses in total wood substance are detected. The effect of brown-rot fungi on wood strength properties is due to cellulose depolymerization. Worldwide losses of millions of dollars annually result from fungal deterioration of untreated or inadequately-treated wood. Several species of brown-rot fungi decay heartwood in living trees. These tree pathogens add to the losses in wood product utilization and threaten forest and plantation stands. Brown-rot fungi represent an untapped resource for industrial bioconversion of lignocelluloses.

13. Performance of Untreated French Guianan Piling in Marine Exposure

Johnson, Bruce R.

1992. In: Proceedings, 23d annual meeting of The International Research Group on Wood Preservation; 1992 May 10-15; Harrogate, Yorkshire, UK. Stockholm, Sweden: IRG Secretariat; Document No. IRG/WP/4173-92: 4 p.

Tropical hardwoods of high natural durability have been of interest as an alternative to pressure treatment with preservatives, some of which are ineffective against marine borers or are environmentally suspect. This paper describes the results of a cooperative study (begun in 1977) by the Forest Products Laboratory of the USDA Forest Service, the International Paper Company, and the U.S. Navy to test the natural durability of seven hardwood species from French Guiana when used as marine piling in a subtropical harbor.

14. Chitin Synthetase Activity in Cellular Fractions of Wood-Decay Fungi

Johnson, Bruce; Croan, Suki; Illman, Barbara.

1992. In: The International Research Group on Wood Preservation. Doc. No. IRG/WP/1524-92. Working Group Ia: Biological problems (Flora). Paper prepared for 23d annual meeting; 1992 May 10-15; Harrogate, Yorkshire, UK: 6 p.

This study was an attempt to explain the variability of *in vivo* sensitivity of wood decay fungi to the chitin synthetase inhibitor, polyoxin, by comparing chitin synthetase distribution in cellular fractions. The five species studied were the brown-rot fungi *Coniophora puteana*, *Gloeophyllum trabeum*, *Fibuloporia vaillantii*, and the white-rot fungi *Schizophyllum commune* and *Ganoderma applanatum*.

15. Effect of Salt Water Evaporation on Tracheid Separation From Wood Surfaces

Johnson, Bruce R.; Ibach, Rebecca E.; Baker, Andrew J. 1992. Forest Prod. J. 42(7/8): 57-59.

This study simulated the seawater wetting of marine piling, which sometimes results in development of fuzzy, brown surfaces just above high tide level. Untreated and treated (chromated copper arsenate (CCA) and creosote) blocks were intermittently wetted with distilled water or synthetic seawater and dried at 54°C. Tracheid separation first became apparent after about 100 wet/dry cycles and gradually became more pronounced. Tracheid separation was more pronounced in latewood than in earlywood and in blocks with a greater retention of CCA. Scanning electron and light microscopy revealed checks along the microfibril angle in tracheid walls of CCA-treated wood repeatedly wetted with seawater.

16. The Effects of CCA-Treated Wood on the Performance of Surface Finishes

Ross, Alan S.; Feist, William C.

1992. In: Proceedings, 87th American Wood-Preservers' Association annual meeting; 1991 April 29-31—May 1; Seattle, WA. Woodstock, MD: American Wood-Preservers' Association: 41-55. Vol. 87.

CCA-treated wood is widely used in residential and commercial decking—prime substrates for surface finishes. Unfortunately, little information has been published on the effects of CCA-treated wood on surface finishes, and many misconceptions exist. This study evaluates the performance of transparent and pigmented commercially available coatings over CCA-treated pine and hem-fir

compared to controls of untreated wood finished with the same products. After 2 years of weathering at sites in Wisconsin and Mississippi, the surface coatings applied to the CCA-treated wood have performed better than those applied to the untreated controls. A mechanism involving interaction and subsequent stabilization of the surface wood components by the chromium (+6) present in CCA is proposed to explain this enhancement of coating performance.

17. Degradation of Fire-Retardant-Treated Plywood: Current Theories and Approaches

Still, Mary Rose; LeVan, Susan L.; Shuffleton, Joseph D.

1991. In: Kocich, Frank, ed. Proceedings of the 1991 3d International symposium on roofing technology; 1991 April 17-19; Montreal, Canada. Rosemont, IL: National Roofing Contractors Association: 517-522.

Premature deterioration of plywood roof decking that has been treated with fire-retardant chemicals has rendered roofs across the United States structurally unsafe and has catapulted cost estimates for potential damage and replacement of damaged plywood into the billions of dollars (U.S.). This paper presents current theories and approaches to fire-retardant-treated plywood.

Energy

18. Practices for Sampling and Testing Wood Fuel in the United States

Baker, Andrew J.

1990. In: Proceedings of the IEA/BETASK VI activity 5 workshop; 1989 October 25-27; Jyväskylä, Finland. Kannus, Finland: Forest Research Institute: 4-6.

The practices for sampling and testing by large industrial users of wood fuel in the United States varies by geographic region, the source of the fuel, and type of industry using the fuel. The practices vary between regions because of the moisture content variations of the tree species of the regions, for example, the moisture content of western species can vary from 40 to 65 percent, whereas in the southeastern states, the moisture content of all of the southern pines is nearly the same. The forest products industries purchase wood fuel in addition to using wood fuel from residues generated internally and the purchased fuel is sampled differently than the internal fuel. It was found that the forest products industry is less concerned about sampling and testing wood fuel than utilities that generate electricity from wood fuel. This paper gives examples of sampling and testing practices of several industries. These examples indicate the range of sampling and testing practices being used.

19. Carbon Syncs and the Control of Greenhouse Gas Emissions by Forest Biomass Production

Zerbe, John I.

1991. In: Klass, Donald L., ed. Energy from biomass and wastes XIV: Proceedings of the 15th annual conference of the Institute of Gas Technology; 1990 January 29-February 2; Lake Buena Vista, FL. Chicago, IL: Institute of Gas Technology: 83-103.

This paper looks at the potential for mitigating atmospheric carbon increase through accumulating more carbon on land by growing forest biomass and by storing carbon in wood products in use. Examples of conservation of energy and reduction of fossil fuel consumption through wood production and use are also presented.

20. Wood as a Material for Conservation of Energy

Zerbe, John I.

1992. In: Wood product demand and the environment: Proceedings, international conference; 1991 November 13-14; Vancouver, BC. Madison, WI: Forest Products Research Society: 223-224.

This paper focuses on the following two areas to reduce the adverse effects of increased atmospheric carbon levels: (1) The utilization of forests can tie up carbon in consumer products for long periods. (2) Using timber instead of steel, concrete, aluminum, plastics, and other energy-intensive materials reduces the fossil fuel requirements and CO₂ production during materials extraction, processing, and use.

Engineering Properties and Design Criteria

21. Behavior of Stress-Laminated Parallel-Chord Timber Bridge Decks: Experimental and Analytical Studies

Dimakis, Al G.; Oliva, Michael G.; Ritter, Michael A.
1992. USDA Forest Serv. Res. Pap. FPL-RP-511. 19 p.

The use of stress lamination for constructing timber bridges may provide a solution to the urgent need for rehabilitating and replacing U.S. highway bridges. This report describes the development, construction, testing, and analysis of a new type of stress-laminated timber bridge: the parallel-chord bridge.

The Performance of Glued Laminated Beams Manufactured From Machine Stress Graded Norwegian Spruce

Falk, Robert H.; Solli, Kjell H.; Aasheim, Erik.
1992. Report No. 77. The Norwegian Institute of Wood Technology, Oslo, Norway. September.

Available from Norsk Treteknisk Institutt (The Norwegian Institute of Wood Technology), Boks 113 Blindern, 0314 Oslo, Norway. No charge.

This study focuses on the characterization of machine stress graded Norwegian spruce laminating lumber and glued-laminated (glulam) timber beams in comparison to CEN standards. Material property testing indicated that the supplied laminating lumber can be represented by two CEN strength classes, C37-14E and C30-12E, with 48 and 50 percent yield, respectively. Beams constructed from these established grades exhibited strength and stiffness meeting the requirements of CEN combinations LH35, LH40, and LC38. Computed laminating factors, K_{lam} , were found to be in the range of 1.05 to 1.15 and are in close agreement with the assumed values of the CEN standards.

22. Creep Behavior Model for Structural Lumber

Fridley, Kenneth J.; Tang, R.C.; Soltis, Lawrence A.
1992. J. Struct. Eng. 118(8): 2261-2277.

An existing four-element viscoelastic model is used to model the creep response of lumber as a function of load and is modified to account for thermal and moisture effects, including mechanosorptive effects (i.e., the nonlinear interaction between applied stress and changing moisture content reflected in the creep response of wood). Creep data from a large population of Douglas-fir nominal 2- by 4-in. (38.1- by 88.9-mm) lumber are used to calibrate the model. The lumber is actually tested to failure as part of a parent

load-duration (creep-rupture) study, but the time-dependent deflections are also monitored. The purpose for monitoring and evaluating the creep behavior of the lumber is to provide insight into the long-term behavior of lumber and develop a general creep model that accounts for load and hygrothermal effects.

23. Load-Duration Effects in Structural Lumber: Strain Energy Approach

Fridley, Kenneth J.; Tang, R.C.; Soltis, Lawrence A.
1992. J. Struct. Eng. 118(9): 2351-2369.

A critical strain-energy-density failure criterion is introduced to describe the load-duration (creep-rupture) behavior of structural lumber. From extensive ramp, constant, and step-constant load tests in various constant and cyclic environments, a critical strain-energy density is identified, which forecasts impending failure. Impending failure is defined as the initiation of member failure, excluding partial failures that do not influence subsequent member behavior. Most previous load-duration research defined failure as the complete collapse of a test member and modeled the response using cumulative damage theory. Select structural and No. 2 grade Douglas-fir nominal 2- by 4-in. lumber are used.

24. Compression Testing of Lumber: A Comparison of Methods

Green, David W.; Evans, James W.
1992. J. Test. Eval., JTEVA. 20(2): 132-138.

A study was conducted to compare compression strength values obtained using short segments cut from full-length lumber and tested in accordance with ASTM D 4761-87 with those values obtained using full-length specimens and tested in accordance with ASTM D 198-84. Tests were conducted on Southern Pine lumber conditioned to a target moisture content of 9 percent. To obtain a short-segment compression strength estimate within a factor of about 1.05 of those obtained by testing full-length (3-m) (10-ft)) specimens, it is necessary to select two of the apparent worst strength-reducing defects in the full-length specimen using ASTM D 245-84 sorting criteria.

25. Improved Performance of Southern Pine Structural Glued-Laminated Timber

Hernandez, Roland; Moody, Russell.
1992. USDA Forest Serv. Res. Pap. FPL-RP-514. 22 p.

This report describes a research study aimed at developing a Southern Pine glulam beam combination with a design bending stress of 3,000 lb/in² and modulus of elasticity of 2.0×10^6 lb/in².

26. Probabilistic Modeling of Glued-Laminated Timber Beams

Hernandez, R.; Bender, D.A.; Richburg, B.A.; Kline, K.S.
1992. Wood Fiber Sci. 24(3): 294-306.

An existing glued-laminated (glulam) timber beam simulation model was refined in this research. This refined model, referred to as PROLAM, incorporates results from recent research on localized lumber and end joint properties. Simulated beams are analyzed for strength using a transformed section method and analyzed for stiffness using a complementary virtual work technique. Other features of PROLAM include user options to proof test individual grades of lumber and to analyze the propagation of end joint and lamination failures that occur during a beam failure.

27. Yield of 2 by 4 Red Oak Stress-Graded Dimension Lumber From Factory-Grade Logs

McDonald, Kent A.; Whipple, James W.
1992. *Forest Prod. J.* 42(6): 5-10.

The objective of this study was to determine stress-graded dimension-lumber yields from graded red oak logs by scaling diameter classes and to compare those yields to the expected factory-lumber yields reported for logs of the same size and quality.

28. Market Forces Will Drive New Engineered Wood Products

Moody, Russell; Collet, Mary P.
1992. *Rural Builder*. March: 30-31.

Today's builders have access to a variety of new structural products, such as prefabricated I-joists, structural composite lumber, and oriented strandboard. This article describes the current direction of research and development for these and future wood products.

29. Nondestructive Testing of Wood

Ross, Robert J.
1992. In: Suprenant, B.A.; Noland, J.L.; Schuller, M.P., eds. *Proceedings, Nondestructive evaluation of civil structures and materials*; 1992 May 11-13; Boulder, CO. Boulder, CO: University of Colorado: 43-49.

During the past 30 years, forest products researchers and the forest products industry have developed and used nondestructive testing tools for a wide range of applications—from the grading of structural lumber to the in-place evaluation of the mechanical properties of individual members in wood structures. The USDA Forest Service, Forest Products Laboratory, recently published a report that reviews NDT techniques used with wood products. This paper provides a brief overview of that report.

30. In-Place Evaluation of Fire-Retardant-Treated Plywood

Ross, Robert J.; Cooper, John; Wang, Zhitong.
1992. In: *Proceedings of the 8th International nondestructive testing of wood symposium*; 1991 September 23-25; Vancouver, WA. Pullman, WA: Washington State University: 247-252.

This paper reviews research on nondestructive testing techniques for in-place assessment of the performance of fire-retardant-treated (FRT) plywood. Two techniques are described in particular: the bending proof load test and the probe or screw withdrawal test. These techniques are currently being used by professionals who inspect roof systems that use FRT plywood.

31. Field Performance of Timber Bridges: 1. Teal River Stress-Laminated Deck Bridge

Wacker, James P.; Ritter, Michael A.
1992. *USDA Forest Serv. Res. Pap. FPL-RP-515*. 19 p.

This report describes the development, design, construction, and field performance of the Teal River bridge located in Sawyer County in northwestern Wisconsin. The bridge, built in 1989, is a two-lane, single-span, stress-laminated deck with a length of 32.5 ft. The bridge design is unique in that it is the first known U.S. application that utilizes full-span structural glued-laminated (glulam) timber beams in a stress-laminated deck.

32. Strength of Bolted Timber Connections With Steel Side Members

Wilkinson, T.L.
1992. *USDA Forest Serv. Res. Pap. FPL-RP-513*. 10 p.

This study investigated the properties of bolted timber connections with steel side members. The intent of this study was to determine (1) how well the European Yield Model (EYM) predicts experimental results, (2) if there is a difference in results from tension- and compression-loaded specimens, and (3) what the effect is of steel side member thickness. Three bolt diameters and four ratios of main member thickness to bolt diameter were investigated. Connections were loaded both parallel and perpendicular to the grain. Results were compared to predicted results from the EYM. The study revealed that the EYM predicts connection yield load with acceptable accuracy.

33. Influence of Initial Kiln-Drying Temperature on CCA-Treatment Effects on Strength

Winandy, J.E.; Barnes, H.M.
1991. In: *Proceedings, 87th American Wood-Preservers' Association annual meeting*; 1991 April 29-31—May 1; Seattle, WA. Woodstock, MD: American Wood-Preservers' Association: 147-152. Vol. 87.

This report interprets recent research that quantified the influence of pretreatment kiln-drying temperature on the effects of chromated copper arsenate (CCA) treatment and redrying on mechanical properties of wood. Using data from previous research, matched specimens of Southern Pine No. 2 and better lumber initially kiln-dried at either 196°F (91°C) or 235°F (113°C).

34. Effects of CCA Treatment and Drying on Tensile Strength of Lumber

Winandy, J.E.; Barnes, H.M.; Mitchell, P.H.
1992. *J. Mater. Civil Eng.* 4(3): 240-251.

This report discusses the influence of initial kiln-drying temperature, copper arsenate preservative treatment, post-treatment redrying temperature, and grade on the tensile properties of Southern Pine dimension lumber.

35. NDS Nail Design Method Comparison

Winistorfer, Steve G.
1992. *Research and Technology*. July/August: 32-44.

The newest edition of the National Design Specification for Wood Construction (NDS), published in 1991, includes major changes in several areas of timber design criteria, several involving mechanical connections. This article discusses changes in lateral and withdrawal nail design and compares the results to those obtained from methods in the 1986 NDS—the NDS edition most familiar to design professionals.

36. Fortran Programs for Reliability Analysis

Zahn, John J.
1992. *USDA Forest Serv. Gen. Tech. Rep. FPL-GTR-72*. 25 p.

This report contains a set of FORTRAN subroutines written to calculate the Hasofer-Lind reliability index. Nonlinear failure criteria and correlated basic variables are permitted. Users may incorporate these routines into their own calling program (an example program, RELANAL, is included) and must provide a failure criterion subroutine (two example subroutines, LINFAIL and YLINEN, are included).

37. Re-Examination of Ylinen and Other Column Equations

Zahn, John J.

1992. *J. Struct. Eng.* 118(10): 2716-2728.

In 1991, Ylinen's column equation was adopted for the design of wood columns in the United States. Ylinen originally derived this equation as a plastic buckling criterion, using a nonlinear compressive stress-strain law as the starting point. The stress-strain law contained a parameter $c \leq 1$, which controlled the degree of nonlinearity. Linearity was achieved at $c = 1$. This same parameter appeared in the final column equation. At $c = 1$, the column equation reduced to elementary theory, i.e., to a perfectly plastic-perfectly elastic failure criterion. Column design equations are viewed in this paper as interaction equations between two modes of failure: crushing and buckling.

Fiber and Particle Products

38. Moisture Sorption Properties of Composite Boards From Esterified Aspen Fiber

Clemons, Craig; Young, Raymond A.; Rowell, Roger M.

1992. *Wood Fiber Sci.* 24(3): 353-363.

The aims of the research reported here were to (1) react wood fiber with different types of anhydrides, (2) determine the plasticization of the reacted wood fiber, (3) make fiberboards with unmodified and esterified fiber using either a thermosetting or thermoplastic resin as binder, and (4) determine the moisture sorption properties of the fiberboards and the rate and extent of swelling in liquid water.

39. Modeling Mechanical Properties of Single-Layer, Aligned, Mixed-Hardwood Strand Panels

Hoover, William L.; Hunt, Michael O.; Lattanzi, Robert C.;

Bateman, James H.; Youngquist, John A.

1992. *Forest Prod. J.* 42(5): 12-18.

Regression equations were estimated to predict the properties of mixed species, single-layer, oriented strand panels. The species used were oak, maple, birch, ash, and aspen.

40. Bonding of Air-Formed Wood Fibre/Polypropylene Fibre Composites

Krzysik, A.M.; Youngquist, J.A.

1991. *Int. J. Adhes. and Adhes.* 11(4): 235-240.

The purpose of this research was to determine if a maleated polypropylene (MAPP) coupling agent could improve the properties of wood fibre/polypropylene fibre composites made by nonwoven web technology.

41. Dry-Process Hardboards From Recycled Newsprint Paper Fibers

Krzysik, A.M.; Youngquist, John A.; Muehl, James M.;

Rowell, Roger M.; Chow, Poo; Shook, Steven R.

1992. *In: Rowell, Roger M.; Laufenberg, Theodore L.; Rowell, Judith K., eds. Materials interactions relevant to recycling of wood-based materials: Proceedings of Materials Research Society symposium; 1992 April 27-29; San Francisco, CA. Pittsburgh, PA: Materials Research Society: 73-79. Vol. 266.*

Dry-process hardboard represents a favorable option for recycling old newspaper fibers. However, dry-process boards tend to be less dimensionally stable than boards processed by other methods. The

objective of this study was to determine the effects of various wood fiber (WF) to old newspaper (ONP) ratios (100:0, 50:50, and 0:100 WF/ONP) on the mechanical strength and water resistance of dry-process hardboards made from these fibers.

42. Recycled Structural Papers: New Approaches for Material Property Improvement

Laufenberg, Theodore L.; Hunt, John F.

1992. *In: Rowell, Roger M.; Laufenberg, Theodore L.; Rowell, Judith K., eds. Materials interactions relevant to recycling of wood-based materials: Proceedings of Materials Research Society symposium; 1992 April 27-29; San Francisco, CA. Pittsburgh, PA: Materials Research Society: 237-241. Vol. 266.*

Although the collection rates and use of recyclable fiber is increasing, more work needs to be done to enhance its performance and to increase its use and acceptance in a wider variety of paper and paperboard products. However, the loss of bonding capability, coupled with a degree of fiber shortening and fiber inflexibility, reduces the utility of recycled fiber and thus their competitiveness with virgin counterparts. This paper reviews some of the traditional and some new approaches that could be used to enhance the performance and use of recyclable fiber.

43. Wood Flour and Polypropylene or High Density Polyethylene Composites: Influence of Maleated Polypropylene Concentration and Extrusion Temperature on Properties

Myers, G.E.; Chahyadi, I.S.; Gonzalez, Carlos;

Coberly, C.A.; Ermer, D.S.

1991. *Int. J. Polym. Mater.* 15: 171-186.

In this paper, the effects of the concentration of a maleated polypropylene additive (0 to 5 percent by weight) and of extrusion blending temperature (190°C to 250°C) on the mechanical properties of extruded and injection-molded polypropylene-wood flour composites were investigated. The effects of maleated polypropylene additive on similarly processed polypropylene-wood flour and high density polyethylene-wood flour composites were also compared.

44. Surface Energy Compatibilities of Cellulose and Polypropylene

Quillin, Daniel T.; Caulfield, Daniel F.; Koutsy, James A.

1992. *In: Rowell, Roger M.; Laufenberg, Theodore L.; Rowell, Judith K., eds. Materials interactions relevant to recycling of wood-based materials: Proceedings of Materials Research Society symposium; 1992 April 27-29; San Francisco, CA. Pittsburgh, PA: Materials Research Society: 113-126. Vol. 266.*

The focus of this research was to investigate the role of surface energy in determining compatibility and adhesion between cellulose (both unmodified and surface-modified) and surface-modified polypropylene.

45. Fiber Based Composites From Recycled Mixed Paper and Magazine Stock

Rowell, Roger M.; Harrison, Sandra.

1992. *In: Rowell, Roger M.; Laufenberg, Theodore L.; Rowell, Judith K., eds. Materials interactions relevant to recycling of wood-based materials: Proceedings of Materials Research Society symposium; 1992 April 27-29; San Francisco, CA. Pittsburgh, PA: Materials Research Society: 65-72. Vol. 266.*

The purpose of this research was to (1) examine the use of these three types of waste paper for fiber-based composites, (2) determine mechanical properties of the composites produced, (3) determine moisture sorption and swelling properties in liquid water of the composites produced, and (4) in the case of the magazine paper, to determine the effect of clay on the properties of the composites produced.

46. Estimation of Fiber-Matrix Interfacial Shear Strengths in Lignocellulosic-Thermoplastic Composites

Sanadi, A.R.; Rowell, R.M.; Young, R.A.

1992. *In: Rowell, Roger M.; Laufenberg, Theodore L.; Rowell, Judith K., eds. Materials interactions relevant to recycling of wood-based materials: Proceedings of Materials Research Society symposium; 1992 April 27-29; San Francisco, CA. Pittsburgh, PA: Materials Research Society: 81-92. Vol. 266.*

The interaction and adhesion between fibers and the matrix in composite materials have a significant influence on the properties of the fiber composite. It is, therefore, of utmost importance to be able to evaluate the properties of the interface/interphase of the fiber-matrix for optimization of the properties of the composites. In this paper, techniques that are currently used to evaluate the properties of this region are discussed with special attention to lignocellulosic-thermoplastic composites. Sample preparation, applicability, problems, and advantages of each technique are highlighted. Results obtained for wood low molecular weight polyethylene systems using the pull-out test are discussed.

47. Fracture Testing Wood Adhesives With Composite Cantilever Beams

Scott, C.T.; River, B.H.; Koutsky, J.A.

1992. *J. Test. Eval., JTEVA. 20(4): 259-264.*

This paper describes a new approach to evaluating wood-adhesive joints being used by the Wood Adhesives Science and Technology Research Work Unit at the Forest Products Laboratory. This test involves the measurement of adhesive fracture toughness in Mode I cleavage. It is an extension of the contoured double cantilever beam test developed by Mostovoy and others and generally follows the procedures outlined in ASTM D 3433.

48. Opportunities for Composites From Recycled Wood Based Resources

Wegner, Theodore H.; Youngquist, John A.;

Rowell, Roger M.

1992. *In: Rowell, Roger M.; Laufenberg, Theodore L.; Rowell, Judith K., eds. Materials interactions relevant to recycling of wood-based materials: Proceedings of Materials Research Society symposium; 1992 April 27-29; San Francisco, CA. Pittsburgh, PA: Materials Research Society: 3-15. Vol. 266.*

A reduction is urgently needed in the quantities of industrial and municipal solid waste materials that are currently being landfilled. Major components of municipal solid waste include waste wood, paper, agriculture wastes, and other biomass fibers. In 1990, there were approximately 80 million tons of wood in the municipal solid waste stream. There are also potential millions of tons of wood fiber in timber thinnings, industrial wood waste, demolition waste, pallets, and pulp mill sludges. These materials offer great opportunities as recycled ingredients in wood-based composites. This paper

discusses possibilities for manufacturing selected composites from these materials as well as materials which coexist with the wood-based resources such as plastics, fly ash, and gypsum.

49. Composites From Recycled Materials

Youngquist, John A.

1992. *In: Proceedings, International Union of Forestry Research Organizations All-division 5 conference "Forest Products;" 1992 August 23-28; Nancy, France. Nancy, France: IUFRO: 137-140. Vol. 1.*

A reduction is urgently needed in the quantities of industrial and municipal solid waste materials that are currently being landfilled. Major components of municipal solid waste include waste wood, paper, plastics, fly ash, gypsum, and other biomass fibers—materials that offer great opportunities as recycled ingredients in wood composites. This paper discusses possibilities for manufacturing selected composites from these materials. Methods for producing the composites and the resultant product properties and attributes are also described.

50. Lignocellulosic—Plastic Composites From Recycled Materials

Youngquist, John; Myers, George E.; Harten, Teresa M.

1992. *In: Emerging technologies for materials and chemicals from biomass: Proceedings of symposium; 1990 August 26-31; Washington, DC. Washington, DC: American Chemical Society; Chapter 4. ACS symposium series 476: 42-56.*

The overall goal of this paper is to illustrate the potential that currently exists for manufacturing thermoformable composites from waste materials such as waste wood, paper, and plastics. First, the availability of such waste materials from municipal solid waste (MSW) streams and the desirability of developing the means to recycle them are discussed. Then, how these composites are made and why materials from the MSW should be suitable ingredients are described. Next, the properties of such composites are illustrated by describing some recent research on the effects of composition and processing variables, using both virgin and recycled ingredients. Following this, an outline of the research and development needed to convert wood fiber and plastics into durable products is given.

51. Mechanical and Physical Properties of Air-Formed Wood-Fiber/Polymer-Fiber Composites

Youngquist, John A.; Krzysik, Andrzej, M.;

Muehl, James H.; Carll, Charles.

1992. *Forest Prod. J. 42(6): 42-48.*

Little data are available on the physical and mechanical properties of nonwoven air-formed wood-fiber and plastic-fiber webs that have been pressed into panels of varying density levels. This study establishes performance properties for panels with densities of 0.4, 0.7, 1.0, and 1.2 g/cm³ and made from three formulations of wood and synthetic fibers (90 percent hemlock and 10 percent polyester; 90 percent hemlock and 10 percent polypropylene; and 80 percent hemlock, 10 percent polyester, and 10 percent phenolic resin).

Fire Safety

Structural Fire Protection

1992. Lie, T.T., ed. Book No. 888. New York, NY: American Society of Civil Engineers Committee on Fire Protection, Structural Division.

Available from American Society of Civil Engineers, 345 East 47th Street, New York, NY. \$56.00 each.

This manual is intended to provide a basis for the development of new standards for the calculation of the fire resistance of structural members. It provides information on current techniques and developments to improve fire safety in buildings. Chapters include building design and fire safety, principles of structural fire protection, fire resistance of building elements, fire temperature-time relations, and temperature and stress distribution in building elements.

52. Fire-Resistive Structural Design

Schaffer, Erwin L.

1991. In: Stalnak, Judith J., ed. Proceedings, International seminar on wood engineering; 1992 April 3; Boston; 1992 April 6; Chicago; 1992 April 8; Seattle; 1992 April 10; Los Angeles. Denver: University of Colorado: 47-60.

To provide fire safety in any structure, many approaches are considered. This involves a combination of (1) preventing fire occurrence, (2) controlling fire growth, and (3) providing protection to life and property. Although attention could be given to all protection techniques available to the building design professional, the scope of this paper is limited to the provisions that prevent fire growth and limit the fire to compartments of origin.

53. Experimental Data on Wood Materials

Tran, Hao C.

1992. In: Babrauskas, V.; Grayson, S.J., eds. Heat release in fires. New York: Elsevier Applied Science. Chapter 11, part b: 357-372.

Many factors have been identified as key variables that affect the burning of wood. They are density, chemical composition, and moisture content. Other factors such as permeability, char contraction factor, and interactions between them should be considered in modeling of wood combustion. Here, a simplified approach is presented, based on empirical correlations and parameters that are available in the literature or readily obtained.

54. Burning Rate of Solid Wood Measured in a Heat Release Rate Calorimeter

Tran, Hao C.; White, Robert H.

1992. Fire Mater. 16: 197-206.

Burning rate is a key factor in modeling fire growth and fire endurance of wood structures. This study investigated the burning rate of selected wood materials as determined by heat release, mass loss, and charring rates. Thick samples of redwood, Southern Pine, red oak, and basswood were tested in a heat release rate calorimeter. Results on ignitability and average heat release, mass loss, and charring rates are reported for a heat flux range between 15 and 55 kWm⁻².

55. Modeling Ignition of Structures in Wildland/Urban Interface Fires

Tran, Hao C.; Cohen, Jack D.; Chase, Richard A.

1992. In: Proceedings, 1st international fire and materials conference; 1992 September 24-25; Arlington, VA. London, UK: Inter Science Communications Limited: 253-262.

With the occurrence of large fire losses in the wildland/urban interface areas, assessing the fire hazard of structures that exist among the wildland fuels is necessary. A USDA Forest Service research team is developing a physics-based model to assess potential hazards of structures in given wildland fire scenarios. This

model integrates a wildland fire module, a flame heat transfer module, and an ignition module. The model examines the major pathways that can lead to ignition: (a) pure radiative heat transfer from the flame, (b) flame impingement, and (c) contact with burning brands. This paper describes the three modules of the model with special emphasis on the ignition module.

56. Fire Endurance Model for Metal-Plate-Connected Wood Trusses

White, Robert H.; Cramer, Steven M.; Shrestha, Deepak K.

1992. In: Proceedings, 1st international fire and materials conference; 1992 September 24-25; Arlington, VA. London, UK: Inter Science Communications Limited: 239-245.

The primary objective of this work was to develop a model and user-friendly computer program that predicts single truss performance under combined structural load and fire conditions. This work included the experimental determination of the load-bearing capacity of 38- by 89-mm (nominal 2- by 4-in.) lumber and metal plate connections under various fire exposures. The test results were used to obtain strength properties at elevated temperatures and to develop and validate thermal degrade models of the components.

General

57. Clear-Cutting, Woody Residue Removal, and Nonsymbiotic Nitrogen Fixation in Forest Soils of the Inland Pacific Northwest

Jurgensen, M.F.; Graham, R.T.; Larsen, M.J.; Harvey, A.E.

1992. Can. J. Forest Res. 22: 1172-1178.

The effect of clear-cutting and woody residue removal on soil nonsymbiotic nitrogen fixation, as estimated by the acetylene reduction technique, was investigated on a subalpine fir (*Abies lasiocarpa* (Hook.) Nutt.) site in western Montana and on a cedar (*Thuja plicata* (Donn ex D. Don) Lindl.)-hemlock (*Tsuga heterophylla* (Raf.) Sarg.) site in northern Idaho.

Microbial and Biochemical Technology

58. Evaluating Isolates of *Phanerochaete chrysosporium* and *Ceriporiopsis subvermispora* for Use in Biological Pulp Processing

Blanchette, Robert A.; Burnes, Todd A.;

Eerdmans, Marjorie M.; Akhtar, Masood.

1992. Holzforschung. 46(2): 109-115.

This paper describes how the decay of birch (*Betula papyrifera*), aspen (*Populus tremuloides*), and loblolly pine (*Pinus taeda*) wood by 19 isolates of *Phanerochaete chrysosporium* showed considerable variation in percentage weight loss and loss of lignin and wood sugars. Birch and aspen woods degraded to a greater extent than loblolly pine wood.

59. Heterologous Protein Expression in Filamentous Fungi

Covert, Sarah F.; Cullen, Daniel J.

1992. In: Leatham, Gary F., ed. Frontiers in industrial mycology. Proceedings of Industrial Mycology symposium; 1990 June 25-26; Madison, WI. New York: Routledge, Chapman and Hall. Chapter 5: 66-77.

This article reviews heterologous expression in filamentous fungi with an emphasis on recent developments and areas requiring further study. Other expression systems, including yeast-like fungi, will only be introduced as points of reference. For additional information the reader is referred to previously published articles.

60. Method to Identify Specific Alleles of a *Phanerochaete chrysosporium* Gene Encoding Lignin Peroxidase

Gaskell, Jill; Vanden Wymelenberg, Amber; Stewart, Philip; Cullen, Daniel.

1992. *Appl. Environ. Microbiol.* 58(4): 1379-1381.

A method to identify and differentiate allelic variants of the gene encoding lignin peroxidase isozyme H8 is presented. The strategy involves amplifying a variable region of the gene's carboxy terminus by use of the polymerase chain reaction and then probing with allele-specific oligonucleotides.

61. Oxidation of Aromatic Pollutants by Lignin-Degrading Fungi and Their Extracellular Peroxidases

Hammel, Kenneth E.

1992. In: Sigel, Helmut; Sigel, Astrid, eds. *Metal ions in biological systems*. Vol. 28. Degradation of environmental pollutants by microorganisms and their metalloenzymes. New York: Marcel Dekker, Inc. Chapter 2: 41-60.

This paper represents Chapter 2 in *Metal Ions in Biological Systems*. The chapter provides a brief introduction and is then divided into two main sections: "Mechanism of fungal ligninolysis" and "Organopollutant degradation by ligninolytic fungi."

62. Use of Fungi in Pulping Wood: An Overview of Biopulping Research

Kirk, T. Kent; Burgess, Richard R.; Koning, John W., Jr. 1992. In: Leatham, Gary F., ed. *Frontiers in industrial mycology*. Proceedings of Industrial Mycology symposium; 1990 June 25-26; Madison, WI. New York: Routledge, Chapman and Hall. Chapter 7: 99-111.

Biopulping is the concept of deliberately harnessing white-rot fungi for pulping. This paper gives an overview of biopulping research to date regarding the use of fungi in pulping wood.

63. The Role of Fungal Lignin-Degrading Enzymes in Xenobiotic Degradation

Lamar, Richard T.

1992. *Environ. Technol.* 3: 261-266.

This review describes recent reports that have verified and extended the understanding of the role of fungal peroxidases and laccases in the degradation of xenobiotic compounds and in the decolorization of bleach plant effluents.

64. Use of Lignin-Degrading Fungi in the Disposal of Pentachlorophenol-Treated Wood

Lamar, Richard T.; Dietrich, Diane M.

1992. *J. Ind. Microbiol.* 9: 181-191.

The objective of this research was to assess, on a laboratory-scale, the ability of lignin-degrading fungi to destroy pentachlorophenol-treated wood from discarded ammunition boxes.

65. White Rot Fungi in the Treatment of Hazardous Chemicals and Wastes

Lamar, Richard T.; Glaser, John A.; Kirk, T. Kent.

1992. In: Leatham, Gary F., ed. *Frontiers in industrial*

mycology. Proceedings of Industrial Mycology symposium; 1990 June 25-26; Madison, WI. New York: Routledge, Chapman and Hall. Chapter 9: 127-143.

This paper describes the lignin-degrading system of *P. chrysosporium*, gives evidence for involvement of the system in the mineralization of xenobiotics, and summarizes research on the use of white-rot fungi to treat effluents from the kraft pulp-bleaching process and to remediate contaminated soils.

66. Composition of American Distilled Tall Oils

Magee, Thomas V.; Zinkel, Duane F.

1992. *J. Am. Oil Chem. Soc.* 69(4): 321-324.

The composition of the acidic components was determined for a cross section of distilled tall oil products produced in the United States. The composition varied widely as a result of different process designs and operations. Filtration of those products that crystallize offers a potential for upgrading some distilled tall oils. In the course of this work, a new resin acid, 7,15-pimaradiene-18-oic acid, was isolated and identified.

67. Roles of Manganese and Organic Acid Chelators in Regulating Lignin Degradation and Biosynthesis of Peroxidases by *Phanerochaete chrysosporium*

Perez, Juana; Jeffries, Thomas W.

1992. *Appl. Environ. Microbiol.* 58(8): 2402-2409.

The objective of this research was to study the effect of manganese and various organic chelators on the distribution, depolymerization, and mineralization of synthetic ¹⁴C-labeled lignins (DHP) in cultures of *Phanerochaete chrysosporium*. The study indicated that manganese peroxidase performs the initial steps of DHP depolymerization but that lignin peroxidase is necessary for further degradation of the polymer to lower-molecular-weight products and mineralization. It was also concluded that a soluble Mn(II)-Mn(III) organic acid complex is necessary to repress LiP.

Mycology

68. Morphological Characteristics of Incompatibility Reactions and Evidence for Nuclear Migration in *Armillaria mellea*

Darmono, T.W.; Burdsall, H.H., Jr.

1992. *Mycologia*. 84(3): 367-375.

This paper describes a technique to identify all the incompatibility genotypes in *A. mellea*. The morphological variability of compatible interactions and evidence of nuclear migration in the A=B⁺ interaction are also discussed.

69. Clamp Connections in North American *Armillaria* Species: Occurrence and Potential Application for Delimiting Species

Larsen, Michael J.; Banik, Mark T.; Burdsall, H.H., Jr.

1992. *Mycologia*. 84(2): 214-218.

Clamp connections were observed in basidiospore dilutions from each of four North American biological species of *Armillaria* (*A. gallica*, *A. sinapina*, *A. ostoyae*, and *A. calvescens*), following spore germination and hyphal anastomosis. Results indicate that clamp connections occur predictably and provide an additional precise and useful criterion for recognizing biological species of *Armillaria*.

70. Reassessment of the Sexual Incompatibility System and Cultural Characteristics of *Bjerkandera fumosa*

Lombard, Frances F.; Larsen, Michael J.;
Dorworth, Elizabeth B.
1992. *Mycologia*. 84(3): 406-410.

In this paper, the sexual incompatibility system of *Bjerkandera fumosa* was determined to be unifactorial and not bifactorial as previously reported. Mon-mon and di-mon confrontations among and between North American and European isolates proved to be compatible. A revised cultural description of *B. fumosa* is provided.

Processing of Wood Products

71. A New Tool for Improving the Drying of Hardwood Lumber

Boone, R. Sidney; Milota, Michael R.; Danielson, Jeanne D.;
Huber, Dean W.

1991. *In: Proceedings, 19th Hardwood Research Council annual symposium; 1991 March 10-12; Starkville, MS. Memphis, TN: Hardwood Research Council: 101-104.*

Within the framework of the IMPROVE System Lumber Drying Program, a new tool has been developed in the form of a guidebook and checklist. This publication helps meet the objective of the Lumber Drying Program to provide easy-to-use methods and techniques that kiln operators can use routinely in the course of normal work around the kilns to improve lumber drying quality operations and to identify sources of drying loss. This paper summarizes this new tool.

72. Press-Drying Plantation Loblolly Pine Lumber to Reduce Warp Losses: Economic Sensitivity Analysis

Simpson, William T.
1992. *Forest Prod. J.* 42(5): 23-26.

In previous studies, warp of plantation-grown loblolly pine, nominal 2- by 4-in. (standard 38- by 89-mm) lumber, which contains a high percentage of juvenile wood, was compared after high-temperature kiln-drying and press-drying. Crook and bow and resultant grade loss were less in the press-dried boards. There are still technical uncertainties about the effectiveness of press-drying in reducing warp, and more research is recommended. However, in addition to more research, it seems worthwhile to analyze some of the economics of press-drying. The objective of this paper was to present estimates of the sensitivity of the economics of press-drying to some of the variables involved.

Pulp, Paper, and Packaging

73. Structural Changes in Cellulose During Papermaking and Recycling

Atalla, Rajai H.
1992. *In: Rowell, Roger M.; Laufenberg, Theodore L.; Rowell, Judith K., eds. Materials interactions relevant to recycling of wood-based materials: Proceedings of Materials Research Society symposium; 1992 April 27-29; San Francisco, CA. Pittsburgh, PA: Materials Research Society: 229-236. Vol. 266.*

This chapter focuses on the structural transformations that occur in cellulosic pulp fibers, with particular emphasis on the effects of

exposure to elevated temperatures in the drying cycle of the papermaking process. Because of the complexity of the structures of cellulose, it is important to recognize, at the outset, that the action of different treatments can occur at different structural levels. This chapter begins, therefore, with a review of the different levels of structure that need to be considered when characterizing celluloses in the native fibrous form. An overview of current thought on cellulose structures is followed by a discussion of some recent studies on the effects of elevated temperatures and the possible effects of mechanical actions. The perspective established is then used as the context for discussing some results of recycling investigations and the issues that must be considered to enhance understanding of recycling processes for paper production.

74. In-Plane Hygroexpansivity of Postage Stamp Papers

Considine, John M.; Bobalek, John F.
1992. *In: Proceedings, TAGA 43d annual technical conference; 1991; Rochester, NY. Rochester, NY: Technical Association of the Graphic Arts: 283-295.*

This paper describes a new method to measure the in-plane hygroexpansivity of paper. The method is used to evaluate the hygroexpansion of stamp papers, with and without adhesive backing.

75. Ink and Speck Dispersion and Removal

Doshi, Mahendra R.; Klungness, John H.
1992. *In: Rowell, Roger M.; Laufenberg, Theodore L.; Rowell, Judith K., eds. Materials interactions relevant to recycling of wood-based materials: Proceedings of Materials Research Society symposium; 1992 April 27-29; San Francisco, CA. Pittsburgh, PA: Materials Research Society: 249-256. Vol. 266.*

Advances in printing technology have posed serious problems for the deinking industry. When ink is fused, as in laser printing and the photocopy process, when water resistant binders are included in coatings or ink formulations, and when varnishes are applied to printed papers, conventional methods fail to disperse inks and specks. The objective of this article is to review different approaches available for removing these inks and specks. Copying processes, coatings, and varnishing processes are discussed prior to discussing deinking and speck removal processes.

76. Forest Service Recycling Research: New Technology for Wastepaper Use

Hamilton, Thomas E.; Laufenberg, Theodore L.
1992. *In: Ride the wave of technology: Proceedings, TAPPI 1992 annual meeting; 1992 March 2-4; Atlanta, GA. Atlanta, GA: TAPPI Press: 373-386.*

In addition to the basic problems of recycling collection, several technical problems must be solved before we can safely, economically, and efficiently handle recyclable paper and wood wastes in the United States. This paper presents high-priority research needs that must be addressed to provide the technical capability for production of a variety of valuable products.

77. Enzymatic Solutions to Enhance Bonding, Bleaching, and Contaminant Removal

Jeffries, Thomas W.; Patel, Rajesh N.; Sykes, Marguerite S.; Klungness, John.
1992. *In: Rowell, Roger M.; Laufenberg, Theodore L.; Rowell, Judith K., eds. Materials interactions relevant to recycling of wood-based materials: Proceedings of Materials*

Research Society symposium; 1992 April 27-29; San Francisco, CA. Pittsburgh, PA: Materials Research Society: 277-287. Vol. 266.

This article reviews some of the literature related to the use of microbial enzymes in recycling secondary fibers and offers a few examples from research. Because this is a rapidly-emerging field, much of the literature is found in patents and symposium proceedings rather than in peer-reviewed journals.

78. Adhesive Contaminants (Stickies) and Methods for Removal

Klungness, John H.; Doshi, Mahendra R.
1992. In: Rowell, Roger M.; Laufenberg, Theodore L.; Rowell, Judith K., eds. Materials interactions relevant to recycling of wood-based materials: Proceedings of Materials Research Society symposium; 1992 April 27-29; San Francisco, CA. Pittsburgh, PA: Materials Research Society: 257-267. Vol. 266.

A variety of adhesive contaminants ("stickies") are encountered in wastepapers. They are broadly classified as hot melts, pressure-sensitive adhesives, and lattices. This paper discusses their properties and control methods. Specifically, control methods include furnish selection, improved pulping and deflaking, well-designed screening and cleaning systems, and dispersion and additives to detackify or stabilize stickies, or both. A new technology is also discussed regarding its possible application for controlling stickie contaminants. Test methods for measuring stickies are also reviewed.

79. Characterization of Paperboard, Combined Board, and Container Performance in the Service Moisture Environment

Laufenberg, Theodore L.
1991. In: Proceedings, 1991 International paper physics conference; 1991 September 22-26; Kona, HI. Atlanta, GA: TAPPI Press; Book 1: 300-304.

A need exists for an industry standard for measuring or predicting the performance of corrugated containers in the dynamic relative humidity environment in which these containers are often transported and stored. At present, no methods are available to properly evaluate the performance of the board components (linerboard, corrugating medium and its combining adhesive) or combined board other than the methods at constant 50 percent relative humidity. A cooperative research program with the USDA Forest Service, Forest Products Laboratory, and the structural paper industry is underway to develop appropriate testing and analysis methodologies to predict the performance of containers. These methodologies will undoubtedly include new standards for the evaluation and specification of corrugated board and component paperboards. This paper describes this research program.

80. The Economic Potential for Improved Fiber Recovery From Recycled Papermills

Marcin, Thomas C.; Klungness, John H.
1992. Forest Prod. J. 42(9): 21-26.

This paper looks at the economic feasibility of improving fiber recovery efficiency by using disk separation to recover fiber and to remove contaminants from mill tailings of secondary newsprint mills. The operating conditions are based on experimental data obtained from fiber recovery experiments performed on mill tailings from a recovered papermill processing old newspapers into recycled newsprint.

81. Recycling Bleach Technologies

Minor, James L.
1992. In: Rowell, Roger M.; Laufenberg, Theodore L.; Rowell, Judith K., eds. Materials interactions relevant to recycling of wood-based materials: Proceedings of Materials Research Society symposium; 1992 April 27-29; San Francisco, CA. Pittsburgh, PA: Materials Research Society: 269-275. Vol. 266.

This report concentrates on the principles of bleaching recycled fibers to the extent that such principles can be generalized. Operating conditions are not discussed.

82. Strength Loss in Recycled Fibers and Methods of Restoration

Minor, James L.; Atalla, Rajai H.
1992. In: Rowell, Roger M.; Laufenberg, Theodore L.; Rowell, Judith K., eds. Materials interactions relevant to recycling of wood-based materials: Proceedings of Materials Research Society symposium; 1992 April 27-29; San Francisco, CA. Pittsburgh, PA: Materials Research Society: 215-228. Vol. 266.

The reduced interfiber bonding capability and reduced conformability of recycled fibers compared to virgin wood pulp fibers is caused by the drying phase of the first papermaking cycle. Changes in the fiber result in stiffness. This effect is more pronounced in chemical pulps than in high lignin content mechanical pulps. This chapter describes methods for restoring some or all of the interfiber bonding. In an attempt to develop a "dry" newspaper recycling process, the water-intensive repulping and paper-forming steps were replaced with dry-fiberizing, air-forming, gas-phase ozone and ammonia treatments, and press-drying. The tensile strength of the dry-recycled paper approached that of the original newsprint.

83. Potential Uses for Peroxymonosulfate in Pulping and Bleaching

Springer, Edward L.
1992. In: Lisius, James D., ed. Proceedings of the 1989 and 1990 AIChE forest products symposium; 1989 November 5-10; San Francisco; 1990 November 11-16; Chicago. Atlanta, GA: TAPPI Press: 113-120.

Practical and cost-effective uses for peroxymonosulfate can be developed in pulping and bleaching. Peroxymonosulfate pulping produces strong pulps, has lower capital requirements, and is less environmentally troublesome compared with current pulping processes. However, the cost of the oxidant may be somewhat too high for practical use. This paper discusses means for reducing the cost and for disposal or recovery of the spent treating liquors.

84. Analysis of the Burst Test Geometry: A New Approach

Strikwerda, John C.; Considine, John M.
1991. In: Proceedings, 1991 International paper physics conference; 1991 September 22-26; Kona, HI. Atlanta, GA: TAPPI Press; Book 2: 579-584.

The burst or Mullen test is used extensively by the paper industry as a quality assurance tool; however, a thorough analysis of this test method is lacking. This paper provides information on previous burst test analyses and gives the details of a new analysis.

Timber Requirements and Economics

85. Economic Potential of North American Timber Resources

Lange, William J.

1992. *In*: Wood product demand and the environment: Proceedings, international conference; 1991 November 13-14; Vancouver, BC. Madison, WI: Forest Products Research Society: 62-75.

This paper has two objectives. The first objective is to examine how public and private research and investment can be used to help achieve the economic potential of North American timber resources. The second objective is to review the timber trends and prospects for North America, thus providing the necessary background for the discussion of research and investment opportunities that follow in this paper.

Tropical Wood Utilization

86. Draft Report on Project PD 72/89 (F)

Reis, Mauro Silva; King, K.F.S.; Daryadi, Lukito; Lindell, Gary; Kemp, Ronald H.; Grut, Mikael.

1990. Permanent Committee on Reforestation and Forest Management, 7th session, 1990 November 16-23. Jokohama, Japan.

This document is a draft report on Project PD 72/89 (F) seminar on sustainable development of tropical forests held in Denpasar, Bali, May 19, 1990.

Wood Bonding Systems

87. Effects of Several Ingredient Variables on Mechanical Properties of Wood Fiber-Polyolefin Composites Blended in a Thermokinetic Mixer

Gonzales, C.; Clemons, C.M.; Myers, G.E.; Harten, T.M. 1992. *In*: Rowell, Roger M.; Laufenberg, Theodore L.;

Rowell, Judith K., eds. Materials interactions relevant to recycling of wood-based materials: Proceedings of Materials Research Society symposium; 1992 April 27-29; San Francisco, CA. Pittsburgh, PA: Materials Research Society: 127-135. Vol. 266.

This study examined the influence of several variables on the mechanical properties of wood fiber-polyolefin composites blended in a thermokinetic mixer.

88. Evaluation of Furfurylamines as Curing Agents for Epoxy Resins

He, Xiaodun; Conner, Anthony H.; Koutsky, James A. 1992. *J. Polym. Sci: Part A: Polym. Chem.* 30: 533-542.

The objective of this study was to evaluate furfuryl amine, tetrahydrofurfuryl amine, and 5,5'-methylenebis-2-furanmethanamine as curing agents for the diglycidyl-ether of bisphenol A (DGEBA, IV). For comparison, parallel reactions of DGEBA with diethylenetriamine (DETA, V) were also studied to rank reactivity of these newer curing agents with a well-known standard curing agent.

89. Polypropylene Crystallization on Maleated Polypropylene-Treated Wood Surfaces: Effects on Interfacial Adhesion in Wood Polypropylene Composites

Kolosick, Paul C.; Myers, George E.; Koutsky, James A. 1992. *In*: Rowell, Roger M.; Laufenberg, Theodore L.; Rowell, Judith K., eds. Materials interactions relevant to recycling of wood-based materials: Proceedings of Materials Research Society symposium; 1992 April 27-29; San Francisco, CA. Pittsburgh, PA: Materials Research Society: 137-154. Vol. 266.

Polypropylene-wood veneer laminates were used as a model system to investigate adhesion in wood-polypropylene composites. An understanding of the adhesive mechanisms involved and how these mechanisms are affected by coupling agents will allow for the rational design of filler-coupling agent systems. This research studied the effects of maleated polypropylene on the adhesion between birch and polypropylene using this model system.

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